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Report No. APG-MT-3285

FINAL REPORT ON

PRODUCT IMPROVEMENT TEST

OF

CARTRIDGE, 81-MM, HE, M374,

WITH REDUCED BOURRELET AND

WATERPROOF IGNITION - PROPELLANT SYSTEM

BY

HARVEY W. CHEATER

AUGUST 1969

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND

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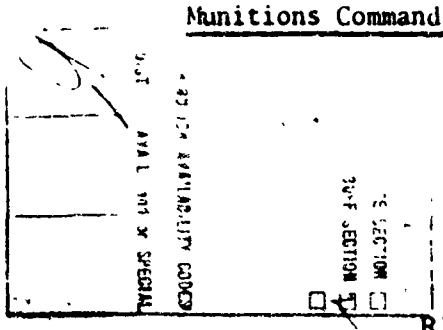

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DEPARTMENT OF THE ARMY
HEADQUARTERS U S ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND MARYLAND 21005

AMSTE-BC

18 SEP 1969

SUBJECT: Final Report on Product Improvement Tests of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Waterproof Ignition/ Propellant System, USATECOM Project Nos. 8-MU-001-374-008/010

Commanding General
US Army Materiel Command
ATTN: AMCRD-W
Washington, D. C. 20315

1. References:

a. Final Report on Product Improvement Test of Cartridge, 81-MM, HE, M374, With Reduced Bourrelet and Waterproof Ignition-Propellant System, USATECOM Project No. 8-MU-001-374-008, Report No. APG-MT-3285, Inclosure 1.

b. Final Report on Product Improvement Test of Cartridge, 81-MM, M374 With Modified Ignition-Propellant System and Reduced Bourrelet, USATECOM Project No. 8-MU-001-374-010, Report No. APG-MT-3311, Inclosure 2.

c. Letter, AMSTE-BC, 27 Jun 1969, subject: Suitability of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Modified Ignition/Propellant System, Inclosure 3.

2. The data contained in references 1a and 1b were available in late June 1969. Review of these data provided sufficient information for USATECOM to establish a position on subject ammunition relative to its suitability for US Army use, reference 1c.

3. The Final Reports at Inclosures 1 and 2 are approved and the USATECOM position forwarded via Inclosure 3 remains unchanged.

FOR THE COMMANDER:

WILLIAM H. HUBBARD
Colonel, GS
Deputy Chief of Staff

3 Incl
as (2 cys ea)

AMSTE-BC 18 SEP 1968

SUBJECT: Final Report on Product Improvement Tests of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Waterproof Ignition/ Propellant System, USATECOM Project Nos. 8-MU-001-374-008/010

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AMSTE-BC

27 JUN 1969

SUBJECT: Suitability of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Modified Ignition/Propellant System

Commanding General
US Army Materiel Command
ATTN: AMCMR-C
Washington, D. C. 20315

1. References:

a. Letter, AMSTE-BC, 7 Mar 69, subject: Suitability of a Product Improved Ignition System for 81mm Mortar Ammunition for US Army Use.

b. Letter Report, STEAP-MT-TA, 24 Jun 69, subject: Letter Report on Product Improvement Test of Cartridge, 81-MM, M374 with Reduced Bourrelet and Waterproof Ignition/Propellant System, USATECOM Project No. 8-9-3010-20, Inclosure 1.

c. Letter Report, STEAP-MT-TA, 24 Jun 69, subject: Letter Report on Product Improvement Test of Cartridge, 81-MM, M374 with Modified Ignition/Propellant System and Reduced Bourrelet, USATECOM Project No. 8-9-3010-26, Inclosure 2.

d. Message, AMCPM-MT 06-1555, 24 Jun 69, subject: TECOM Evaluation of 81mm Waterproof Propellant Ignition System.

2. Background:

a. An accelerated effort to provide a waterproof ignition/propellant system for the 81mm Cartridge, M374 has been underway for approximately two years. Several propelling increment bag materiels were tested that provided adequate water protection, however, problems relating to either residue buildup in the mortar or lack of durability during handling tests resulted in rejection of these materiels. Extensive testing was then conducted with a Celcon/silk bag materiel which performed satisfactorily relative to tube residue and provided some degree of moisture protection. Concurrent with the Celcon/silk increment testing, Picatinny Arsenal

product improvement testing on a modified M149 Fin Assembly with 24 - 0.125 inch diameter ignition flash holes was underway at Aberdeen Proving Ground.

b. The cartridge employing the Celcon/silk increment consisted of the shell, M374 with reduced bourrelet; a mylar wrapped Ignition Cartridge, M66; a potted primer; and the standard Fin Assembly, M149. The cartridge employing the modified fin assembly described above, however, utilized a modified ignition Cartridge, M66 with 108 grain charge weight without brass liner and wrapped with 1 mil mylar, and the standard Propelling Charge, M90. The latter system was deemed suitable for US Army use by reference 1a, however, since the system offered no significant advantage relative to waterproofness over the current standard, the Product Manager for Mortar Ammunition directed USATECOM to conduct an independent evaluation on the "standard cartridge" with Celcon/silk increments under USATECOM Project No. 8-9-3010-20. During the period of preparing the plan of test and submission of the test materiel to APG, Picatinny Arsenal submitted a quantity of cartridges with modified fin assembly and Celcon/silk increments for testing that paralleled the plan for USATECOM Project No. 8-9-3010-20. This program was conducted under USATECOM Project No. 8-9-3010-26.

c. Because of the parallel testing, this command is in a position to evaluate both systems, consequently, this correspondence addresses both ignition/propellant systems.

3. Test Results.

a. With reference to Cartridge, M374 having a reduced bourrelet and Celcon/silk increments:

(1) Test results disclose all test criteria were met except the following:

(a) An increase in propellant bag damage over the cotton increment resulted during the sequential rough handling tests. No damage, however, resulted from the simulated transportation-vibration test.

(b) At fixed charge weights, the velocity levels of the test cartridge at 70°F are significantly different than the control cartridge at all charges except charge 4.

(c) Very large variability in velocity and depressed levels resulted in a total of 104 short rounds of 149 fired after being subjected to water immersion and rain tests.

(2) The time to cook-off of misfired cartridges is considerably less than that of the current standard.

b. With reference to Cartridge, M374 having a reduced bourrelet, modified fin assembly and Celcon/silk increments:

(1) Test results disclose all test criteria were met except for the following:

(a) Although not tested it can be stated with assurance that the above cartridge can be expected to undergo propellant bag damage when subjected to the sequential rough handling tests.

(b) At fixed charge weights, the velocity levels of the test cartridge at 70°F are significantly different than the control cartridge at all charges except charge 3.

(2) Relatively small velocity dispersions or effects on level yielded a total of five short rounds of 150 fired after being subjected to water immersion and rain tests.

4. Comments. The following comments are pertinent:

a. Paragraphs 3a(1)(a) and 3b(1)(a) - Since the metal parts of both cartridges tested are identical except for the number and size of flash holes in the cartridge container and the method of increment attachment is identical, subjecting either test cartridge to the sequential rough handling and transportation-vibration tests is considered a valid approach. Cartridges utilizing polystyrene muffs around the Celcon/silk propellant increments have successfully passed rough handling tests conducted under a Picatinny Arsenal Test Program Request 690.

b. Paragraphs 3a(1)(b) and 3b(1)(b) - Velocity data indicates that a propellant charge assessment in lieu of a change to the existing firing tables will be a suitable solution to the velocity mismatch with either test cartridge.

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SUBJECT: Suitability of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Modified Ignition/Propellant System

c. Reference is made to paragraph 3a(2) and paragraph 3c of reference 1b - The differences in cook-off sensitivity between the Celcon/silk and cotton increments are in two interrelated areas. Firstly, cook-offs occur in considerably less time after a misfire with Celcon/silk increments than with cotton increments. Secondly, the burning characteristics of the two types of increments are significantly different; cook-off energy levels with cotton increments result in low exit velocities whereas high velocity levels result with Celcon/silk incremented cartridges. The attainment of "full velocity" during cook-off with the latter cartridges may be considered as an asset in that short rounds will not result. Provided the misfire procedures outlined in FM 23-90 dated January 1967 are followed, no additional safety hazards should be encountered.

d. All statements made with reference to the HE Cartridge, M374 are also applicable to the WP Cartridge, M375.

5. Conclusions:

a. The Cartridge, HE, M374, with reduced bourrelet, standard ignition system and Celcon/silk propellant increments provides a replacement for the present Standard A cartridge with some improvement in moisture protection, but not to the degree of being a suitable water/moisture resistant round.

b. The Cartridge, HE, M374 with reduced bourrelet, modified ignition system and Celcon/silk increments offers a significant improvement relative to water/moisture resistance over the current standard and is considered suitable for US Army use.

6. Recommendations:

a. Polystyrene muffs be considered for incorporation into packaging as additional protection for Celcon/silk increments.

b. To further define sensitivity of propellant increment ignition prior to primer contact during very high sustained rates of fire, additional firings be imposed. This data is not considered a prerequisite for AMCTC action.

FOR THE COMMANDER:

William H. Hubbard

WILLIAM H. HUBBARD
Colonel, GS
Deputy Chief of Staff

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SUBJECT: Suitability of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Modified Ignition/Propellant System

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(16) USATECOM [redacted]-8-MU-001-374-008

(6)

PRODUCT IMPROVEMENT TEST OF
CARTRIDGE, 81-MM, HE, M374, WITH REDUCED
BOURRELET AND WATERPROOF IGNITION - PROPELLANT SYSTEM.

(9) FINAL REPORT. 1 May - 15 Jul 69,

BY

(10) HARVEY W. CHEATER

(11) AUG[redacted]969 (12) 61p.

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ABERDEEN PROVING GROUND
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ABSTRACT

A product improvement test was conducted at Aberdeen Proving Ground on an 81-mm cartridge, HE, M374, modified with a reduced bourrelet and a waterproof ignition - propellant system from 1 May to 12 June 1969. This test was conducted to determine whether the modifications to the round provided waterproofness properties to the propellant without adversely affecting velocity, pressure, and range and without introducing safety or human-factors problems. The test round was found to be only a marginal improvement over the standard round in eliminating short rounds following waterproofness tests. Velocity levels were significantly higher for the test round at all charges but charge 4 when compared with the standard round at +70°F. This difference would require an adjustment of the propellant charge or a correction to the existing firing tables. Residue did not appear to be a problem nor was safety degraded by the modification. Cook-off properties were remarkably different in that the test round is launched at apparent full velocity. The obvious advantage is that a live round does not impact close to the mortar position. If established misfire-removal procedures are followed, no safety problem is created. The test bags required significantly longer time (as much as 75% longer) to assemble to the round than the cotton increment and are more susceptible to detaching from the round during rough-handling tests. However, the latter can be prevented by assembling the test rounds with protective muffs. It is concluded that the test cartridge provides a replacement for the present standard round with some moisture protection but not to the degree of being a suitable water - moisture resistant round and that the difference in velocity levels of the two cartridge types is significant. No human-factors or safety problems were encountered.

FOREWORD

Materiel Test Directorate was responsible for writing the test plan, conducting the test, and preparing the test report.

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND 21005

USATECOM PROJECT NO. 8-MU-001-374-008

FINAL REPORT ON PRODUCT IMPROVEMENT TEST OF CARTRIDGE, 81-MM, HE, M374, WITH REDUCED BOURRELET AND WATERPROOF IGNITION - PROPELLANT SYSTEM

1 MAY TO 12 JUNE 1969

SECTION 1. INTRODUCTION

1.1 BACKGROUND

The 81-mm, HE cartridge, M374, and its WP counterpart, M375, have not had a waterproof ignition - propellant system. As a result, short rounds and misfires have occurred in the field when these cartridges were exposed to excessive moisture. As an interim solution to this moisture problem, 81-mm mortar ammunition is currently supplied to the field in a fiber container, which in turn is "Jungle Wrapped." To provide a permanent solution to the problem, Picatinny Arsenal developed a moisture-resistant ignition - propellant system for use with the current 81-mm mortar ammunition.

The waterproof ignition system has already been successfully tested and is now being introduced into production. This report covers an independent evaluation of the cartridge using a waterproof system to augment the waterproof ignition system.

1.2 DESCRIPTION OF MATERIEL

The test ammunition is the M374, HE cartridge having a shell body modified by a 0.010-inch reduced bourrelet (3.172 -0.005-inch diameter before paint and 3.174-inch maximum after paint) and assembled with a welded split-ring delrin obturating band, a potted primer, M71A1E1, a mylar-wrapped ignition cartridge, M66E1, potted into the fin assembly with room temperature vulcanizing (RTV), folded Celcon/silk propellant bags, and a standard fin and boom.

1.3 TEST OBJECTIVES

The objectives of this test were:

a. To determine if the waterproofed ignition - propellant system provides sufficient protection against moisture to eliminate or significantly reduce the occurrences of short rounds.

b. To determine if pressure, velocity, and range are affected by the waterproofed ignition - propellant system and the bourrelet reduction.

c. To assure that no safety or human-factors problems have been introduced into the system.

d. To determine suitability of the test item for US Army use as an alternate for the current standard cartridge.

1.4 SUMMARY OF RESULTS

1.4.1 Residue Test

Six hundred test cartridges were fired in 50-round groups at charges 1, 2, 3, 2, 4, 2, 5, 2, 7, 2, 9, and 2. No misfires occurred. The twenty-third round of charge 2 after charge 7 hung up in the tube and fired when the tube was struck.

No measurable amount of residue was found in the weapon following each 50-round group. A brown coating, presumably from the brass ignition - cartridge liner, had formed on the inside of the tube. This coating was readily removed with steel wool when the tube had cooled.

1.4.2 Waterproofness Test

Approximately 50% of the test bags leaked following the 2-hour immersion and there was some leakage noted following the 10-minute soak. No leakage was noted following the rain test.

Velocities obtained with the test and control rounds which were subjected to the various waterproofness tests are contained in Table 1.4-I.

Table 1.4-I. Summary of Velocity and Short Rounds For Celcon/Silk (Test) and Cotton (Control) Increments

Test Phase	Test Rounds: No. Rounds Fired	Test Rounds: No. Rounds Short[a]	Test Rounds: Velocity, fps: No. Rds Cons[b]	Test Rounds: Velocity, fps: Avg	Test Rounds: Velocity, fps: Std Dev	Test Rounds: Velocity, fps: Min	Test Rounds: Velocity, fps: Max	Control Rounds: No. Rounds Fired	Control Rounds: No. Rounds Short[a]	Control Rounds: Velocity, fps: No. Rds Cons[b]	Control Rounds: Velocity, fps: Avg	Control Rounds: Velocity, fps: Std Dev	Control Rounds: Velocity, fps: Min	Control Rounds: Velocity, fps: Max
Charge 4														
Puddle	15	4	15	521	21	483	558	10	8	10	416	129	146	525
10-minute soak	15	10	11	454	102	200	541	[c] 2	2	0	-	-	-	-
2-hour soak	15	12	14	288	201	88	571			Not fired				
10-minute rain	10	9	9	405	109	156	513	5	5	4	408	110	250	500
1/2-hour rain	10	4	10	498	75	298	545	5	5	5	388	95	284	542
2-hour rain	10	9	9	376	118	232	551	5	5	3	262	147	126	418
10-day humidity	15	0	15	568	3.0	562	572	10	0	9	571	2.9	567	575
Expected velocity[d]				584							580			
Charge 9														
Puddle	15	10	9	715	84	569	796	[c] 2	2	-	-	-	-	-
10-minute soak	15	[e] 8	10	620	372	51	862			Not fired				
2-hour soak	15	15	[f] 5	307	307	72	672			Not fired				
10-minute rain	10	7	6	635	220	301	826	5	5	0	-	-	-	-
1/2-hour rain	9	7	5	653	165	432	806	5	5	0	-	-	-	-
2-hour rain	10	9	3	551	375	127	[g]841	5	5	0	-	-	-	-
10-day humidity	15	0	15	852	4.4	843	857	10	0	10	859	4.0	852	866
Expected velocity[d]				873							869			

Footnotes on following page.

1.4.3 Velocity-Uniformity Test

A velocity comparison between the test and control rounds at various charges and temperatures is contained in Table 1.4-II.

Except as noted, these data were obtained for 10-round groups.

1.4.4 Cook-Off Test

Both the test and control cartridges were subjected to cook-off tests. The temperature of the weapon when the rounds were inserted into the weapon and the temperature and elapsed times at cook-off are contained in Table 1.4-III.

[a]Less than 80% of expected range (estimated from velocity or actual observation).
[b]Velocities of some rounds were too low to be sensed by the chronograph.
[c]Testing with the control round was discontinued for the soak phase due to extremely short ranges (less than 50 feet).
[d]These data are extracted from velocity - uniformity summary.
[e]Remaining seven rounds were allowed to dry 1/2 hour. Velocities ranged from 819 to 862 fps.
[f]Four of these rounds were allowed to dry up to 55 minutes.
[g]Two rounds which were wiped with a rag had velocities of 685 and 841 fps.

Table 1.4-II. Summary of Velocity Mean and Standard Deviation For Test and Control Rounds

	Velocity, fps				
	Test Round		Control Round		Difference
Charge	Avg	Std Dev	Avg	Std Dev	Test - Control
			-65°F		
2	[a]416	4.3	[b]415	3.0	+1
4	[a]548	2.1	[a]545	4.1	+3
9	845	6.3	842	7.1	+3
			+145°F		
2	[c]442	1.3	[a]441	1.5	+1
4	593	2.8	592	2.2	+1
9	[c]890	2.0	887	1.2	+3
			+70°F		
1	[c]352	1.4	348	1.2	+4
2	[c]435	2.3	[d]430	2.9	+5
3	[c]516	2.8	[d]511	3.5	+5
4	584	1.4	580	2.6	+4
5	[c]650	2.7	644	3.0	+6
6	[c]710	2.3	705	2.3	+5
7	[c]765	1.8	760	3.0	+5
8	[c]812	7.6	[d,e]806	5.9	+6
	[c,d,e]815	4.0	[d,e]808	3.3	+7
9	[c]873	2.5	869	1.7	+4

[a]Nine rounds only.
[b]Seven rounds only.
[c]Significantly different from control round at 95% level.
[d]Eight rounds only.
[e]First two rounds omitted since test was begun with charge 8 and baseplate was not firmly seated.

Table 1.4-III. Summary of Cook-Off Times and Tube Temperatures

Test Cartridge				Control Cartridge			
Wpn Temp[a], °F		Time to		Wpn Temp[a], °F		Time to	
At Insertion	At Cook-Off	Cook-Off, sec	Apparent Vel[b]	At Insertion	At Cook-Off	Cook-Off, sec	Range, feet
705	685	13	Full	712	675	22	40
690	680	8	Full	675	575	47	62
682	660	13	Full	575	505	38	32
610	600	12	Full	628	565	38	75
605	545	43	Full	565	440	89	75
550	[c] -	-	-	535	[c] -	-	-
527	525	[d] 5	Full	-	-	-	-
532	[c] -	-	-	-	-	-	-
415	[c] -	-	-	-	-	-	-

[a]At 36 inches from the muzzle.
[b]Velocities were not measured.
[c]Did not cook-off.
[d]Bag may have touched hot barrel.

1.4.5 Sequential Rough-Handling Test

Several test rounds were found to have loose or completely detached increment bags following the various subtests of the rough-handling phase. Six test bags conditioned to -65°F and one at +70°F were broken open allowing propellant to spill out following the bump test.

After the 5-foot unpackaged drop test, two test bags at -65°F and one at ambient temperature were broken open.

The only damage suffered by the control round was the detachment of four increment bags at the fin end following the 5-foot unpackaged drop. The control round was tested at ambient temperature only.

Both the test and control rounds were assembled with plastic water-barrier bags over the propellant charges.

These rounds which successfully completed the rough-handling test were fired for velocity. Results are shown in Table 1.4-IV.

1.4.6 Transportation - Vibration Test

No damage was incurred by the test or control rounds subjected to a transportation - vibration test.

A summary of velocity data obtained when vibrated and non-vibrated rounds were fired is contained in Table 1.4-IV.

Table 1.4-IV. Summary of Velocity Data for Rounds Subjected to Sequential Rough-Handling and Transportation - Vibration Testing

Type Cartridge	Cartridge Temp	No. Rds	MV, fps Mean	MV, fps Std Dev
		Sequential Rough-Handling Test		
Test	Ambient	12	853	23.6
		[a] 8	869	2.7
Test	-65°F	10	859	22.8
		[a] 8	870	3.3
Control	Ambient	24	869	4.4
		Transportation - Vibration Test		
Test	Ambient	24	871	4.3
Control	Ambient	24	868	3.6
		No Previous Treatment[b]		
Test	Ambient	[c] 9	861	6.1

[a]Six rounds were thought to have been fired at charge 8.
[b]Fired as a reference.
[c]Velocity of one round was lost.

1.4.7 Human Factors

Average times required to remove and reassemble the test and control increments are contained in Table 1.4-V.

Table 1.4-V. Summary of Times Required to Remove and Replace Propellant Bags for Test and Control Rounds

Operation	Gunner	Trial[a]	Average Time, seconds	
			Test Round	Control Round
Charge 9 to 4	A	1	20.4	19.9
		2	12.0	9.5
	B	1	15.5	12.0
		2	13.3	11.3
Charge 4 to 9	A	1	50.5	37.3
		2	52.7	30.6
	B	1	62.2	37.7
		2	46.7	26.4
Charge 9 to 0	A	1	23.2	20.0
		2	25.8	17.0
	B	1	20.5	19.2
		2	23.4	16.8
Charge 0 to 9	A	1	85.5	57.4
		2	92.3	55.5
	B	1	79.2	59.5
		2	88.0	51.8

[a]Each trial conducted with five rounds.

1.4.8 Removal of Misfires

No difficulty was incurred and no change in the operation was required to remove misfired test rounds. However, since the test round cooks-off at apparent full velocity (paragraph 1.4.4), a safety hazard could exist in attempting to dump the round before the likelihood of a cook-off is past. Present procedures are adequate for the modified cartridge. Based on the results in paragraph 1.4.4, the time to cook-off is less than 1 minute.

1.5 CONCLUSIONS

It is concluded that:

a. The cartridge, HE, M374, with the waterproof ignition and propellant system and reduced bourrelet diameter provides a replacement for the present standard A cartridge with some improvement in

moisture protection, but not to the degree of being suitable water - moisture resistant round (ref par. 1.4).

b. Significant differences from the standard cartridge exist in the velocity and range with the test cartridge (ref par. 2.4.5).

c. No safety-factor problem was introduced into the system. Although cook-offs with the test cartridge occur at full velocity, they occur in less than 1 minute (ref par. 2.5.5).

d. No human-factor problem was introduced into the system except longer time to reassemble increments (ref par. 2.8.5).

1.6 RECOMMENDATIONS

Not applicable.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

This test was conducted as an independent evaluation of an 81-mm cartridge incorporating four modifications each of which has been previously evaluated. These modifications include a 1-1/2 mil-thick Celcon/silk increment bag, a welded split delrin obturator, a steel body with a reduced bourrelet diameter (0.010-inch reduction), and a mylar-wrapped ignition cartridge potted to the fin assembly with RTV.

Tests were conducted to evaluate waterproofness of the test cartridge and to determine whether this round is compatible with the present M374 cartridge both ballistically and with safety, training, and human-factors considerations.

This section describes the various subtests conducted.

2.2 RESIDUE TEST

2.2.1 Objective

The objective was to determine if the test cartridge will fire properly without excessive misfires.

2.2.2 Criterion

There shall be less than 1% misfires caused by propellant bag residue remaining in the tube.

2.2.3 Method

With the mortar elevated to 45°, 50 rounds each at charges 1, 2, 3, 2, 4, 2, 5, 2, 7, 2, 9, and 2 at ambient temperature were fired at a rate of 12 rounds per minute. The tube was inspected, then dry-swabbed and allowed to cool after each charge.

2.2.4 Results

No misfires occurred. Round 23 of charge 2 after charge 7 hung up in the tube. This round fired when the tube was struck.

Very little bag residue was found in the tube or on the swab after each 50-round group. A brown deposit formed on the bore of the

weapon following the 50 rounds at charge 1 and was removed with steel wool at the end of the first day's firing (following charge 2 after charge 5).

On the following day the coating appeared after firing the first 50 rounds (charge 7) and was present throughout the remainder of this phase. At no time did this coating interfere with loading or firing of a round.

2.2.5 Analysis

The test criterion was met. Whether or not the coating caused the hangup to occur is unknown. However, since no further problems were encountered, the presence of the coating does not appear to be detrimental.

2.3 WATERPROOFNESS TEST

2.3.1 Objective

The objective was to determine if the bare test cartridge has sufficient protection against moisture to eliminate or significantly reduce the current problem with low velocities resulting in short rounds.

2.3.2 Criterion

The test cartridge performance shall be significantly improved over the control cartridge when subjected to total immersion, rain, and a 10-day humidity test.

2.3.3 Method

2.3.3.1 Puddle Test. To simulate the dropping of a cartridge into a puddle, each round in this phase was immersed in water to a depth of 4 or 5 inches for 2 seconds. Then the round was withdrawn, shaken of all excess water, and loaded in the muzzle of the weapon and lanyard-fired.

2.3.3.2 Immersion Test. Bare rounds were placed nose down in a barrel of water so that the primers were approximately 1 foot beneath the surface. Fifteen test and three control rounds at charge 4 and the same number at charge 9 were allowed to soak for 10 minutes. A similar group was immersed for 2 hours.

At the end of each time limit, all rounds at a given charge were removed from the water at one time and placed horizontally on a table for firing. Each round was shaken to remove the water prior to firing.

Velocity and elapsed drying time were recorded for each round.

2.3.3.3 Rain Test. Groups of ten test and five control rounds each at charges 9 and 4 were subjected to a simulated rain test for periods of 10 minutes, 1/2 hour, and 2 hours.

The bare rounds were placed horizontally on a drainboard while a spray from a garden hose was directed upwards and allowed to fall on the rounds. The flow was regulated to provide a rate of 4 $\pm$ 1 inch per hour. Use of the drainboard insured that the rounds did not lay in a puddle of water during this test.

At the end of each time period, the rounds were removed from the rain facility and placed in containers for transport to the firing site. The rounds were kept in containers until ready for firing. As before, the rounds were shaken prior to firing. Velocity and the elapsed time from removal of the round from the rain facility until the round was fired were recorded.

2.3.3.4 Humidity Test. Thirty bare test rounds and 20 control rounds were subjected to the 10-day warm - wet humidity cycle referred to as Schedule A in MTP-4-2-820 (Interim Pamphlet 70-84). Half the rounds were at charge 4 and half at charge 9.

Upon completion of the cycle, the rounds were removed five at a time and placed in containers for transport to the firing site. The temperature - humidity cabinet was maintained at the final cycle conditions (+70°F and 95% humidity) until all rounds were fired.

2.3.4 Results

2.3.4.1 Puddle Test. At charge 4, the velocity of the control round varied from 146 to 525 fps. Eight of ten rounds had velocities which would result in short ranges (defined as less than 80% of the anticipated ranges). The test round resulted in four out of 15 with short ranges using the same criterion.

At charge 9, ten of 15 test rounds had short ranges. Two control rounds were fired but the velocities were too low to be sensed by the solenoid coils. No more control rounds were fired in this phase.

2.3.4.2 Immersion Test. Following the 10-minute soak, two control rounds at charge 4 were fired. Each had a range of only 40 to 50 feet. Testing with this round was suspended.

Of 15 test rounds at charge 4, four had velocities too low to measure and only one had an acceptable velocity (541 fps).

Five test rounds at charge 9 were fired within 8 minutes of removal from the water. All rounds either had velocities too low to be detected or failed to pass through the second velocity coil.

Three rounds which were dried 15, 16, and 18 minutes showed velocities of 92, 51, and 105 fps respectively.

The remaining seven rounds were allowed to dry for 1/2 hour and attained velocities ranging from 819 to 862 fps.

No control rounds were fired since poor results were obtained at charge 4.

After 2 hours of immersion, ten test rounds were fired with only 3 to 10 minutes of drying time. The velocity of the first round was too low to record. The tenth round had a velocity of 449 fps while remaining rounds exhibited velocities ranging from 88 fps (round 4) to 288 fps (round 6). Rounds 11, 13, and 15 with 18 to 21 minutes of drying time were wiped dry on the exterior of the charges. Velocities of these rounds were, in order, 556, 571, and 390 fps. Rounds 12 and 14 with drying times of 19 and 20 minutes were fired without wiping the charges. Their velocities were 539 and 493 fps respectively.

When the test rounds at charge 9 were fired, seven rounds with drying times as long as 1/2 hour had velocities too low to record. One round fired after 35 minutes had a velocity of 94 fps while a round fired immediately afterward and another fired 5 minutes later were too low to record.

After a total of 51 minutes drying time, testing was resumed and the remaining six rounds were fired in approximately 5 minutes. Two velocities were too low to be sensed and the remaing rounds had velocities of 672, 84, 613 and 72 fps respectively. All were short rounds.

Inspection of the charges prior to firing indicated that water had leaked into approximately 50% of the test bags during the 2-hour immersion. There was evidence of some leakage on the rounds removed after 10 minutes.

2.3.4.3 Rain Test. Nine of ten test rounds fired at charge 4 following the 10-minute rain test had ranges estimated to be less than 80% of desired range. One of the nine rounds had a velocity too low to be sensed.

All five control rounds at this charge were short, and one was not sensed.

At charge 9, only three of ten test rounds had acceptable velocities; four were too low to be recorded. All five control rounds impacted less than 100 yards from the weapon and velocities could not be recorded.

Ten charge 4 test rounds exposed to 30 minutes of rain were fired within 20 minutes of removal from the facility. Four had unacceptable velocities. All five control rounds fell short and the velocities could not be obtained.

At charge 9, seven of nine test rounds (one round was inadvertently omitted) and all five control rounds had short ranges. No velocities could be obtained for four test rounds or for any of the control rounds.

After the 2-hour rain test, nine of ten test rounds and all five control rounds fell short when fired at charge 4. When tested at charge 9, only one of the first seven test rounds had a measurable velocity (127 fps). Rounds 8 and 9 were wiped on the outside with a rag and attained velocities of 685 and 841 fps. Round 10 which was not wiped did not pass through the second velocity coil.

None of the control rounds was able to pass through the second velocity coil.

2.3.4.4 Ten-Day Humidity Cycle. Inspection of the rounds following the 10-day warm - wet humidity cycle showed a brownish discoloration of the Celcon/silk (test) bags. No breaking or tearing of the bags was noted, nor was weakening of the bags evident as an attempt was made to break open the bags by crushing several of them by hand.

The control round (with cotton bags) showed no discoloration or apparent effects resulting from the humidity test.

Upon firing, no short rounds occurred with either type round when fired at charges 4 and 9. Contrary to previous results, the test round had a lower average velocity than the control round at both charges. The velocities were 852 and 859 fps for the test and control rounds at charge 9 and 568 and 571 fps respectively at charge 4. These velocities are significantly different at the 95% confidence level.

Very little bag residue was found in the weapon after each round. However, upon completion of the firing, a slight build-up in the form of streamers along the axis of the weapon was noted.

2.3.5 Analysis

The Celcon/silk increment bag provides a marginal improvement in waterproofing the propellant for the 81-mm cartridge, M374.

Two distinct problem areas were noted; namely, water on the outside of the bag and leakage into the bag.

When the seven rounds, charge 9, subjected to the 10-minute soak were air-dried and the two rounds from the 2-hour rain test were wiped with a rag, near-normal velocities resulted.

On the other hand, a 1-hour drying time produced only a marginal improvement following the 2-hour immersion at charge 9. It can be stated that leakage into the bags was the cause for the short rounds in this instance.

2.4 VELOCITY-UNIFORMITY TEST

2.4.1 Objective

The objective was to determine if the velocity characteristics of the test cartridge are significantly different from those of the standard M374 cartridge.

2.4.2 Criteria

Criteria are as follows:

a. The velocity levels of the test and control cartridges shall not differ significantly at the 95% confidence level. The standard deviation of the test cartridge shall not be significantly worse than that of the control cartridge at the same level.

b. No individual peak chamber pressure with the test cartridge conditioned at +145°F shall exceed 10,600 psi.

2.4.3 Method

Ten test rounds and ten control rounds each at charges 1 through 9 were conditioned to +70°F. Twenty additional rounds each type were assembled at charges 2, 4, and 9. Half were conditioned to -65°F and half to +145°F. All rounds at a given charge and temperature were fired by alternating test and control rounds.

Velocity was measured for all rounds while pressure was measured for the charge 9 rounds only.

2.4.4 Results

The velocity level of the test round was higher than that of the control round for all charges and temperatures. This difference was significant at the 95% level for all charges at +70°F with the single exception of charge 4. Specific values are shown in Table 1.4-II.

The highest individual pressure obtained was 9300 psi with the test rounds conditioned to +145°F.

A number of misfires and hangups occurred with the control round which was fired alternately with the test round. Three misfires resulted with charge 2 and one with charge 4 when the rounds were conditioned to -65°F; one charge 3 round misfired at +70°F. A light residue was found on the obturator of each round when the tube was dumped. All rounds were wiped clean and subsequently test-fired upon completion of the day's test. All fired properly.

Eight control rounds hung up and fired when the tube was struck. These were: one charge 4 at -65°F, two charge 2 at +145°F, and one charge 2, one charge 3, two charge 4, and one charge 5 at +70°F.

No similar problems occurred with the test rounds.

2.4.5 Analysis

The difference in velocity, which is statistically significant for all but one charge, could be corrected by an adjustment in the charge of the A-increment bag or by a correction to the range table (page III-6).

The introduction of the Celcon/silk should not result in a pressure problem with top charge when conditioned to +145°F.

2.5 COOK-OFF TEST

2.5.1 Objective

The objectives were:

a. To determine if the test cartridge will increase the danger of a cook-off as compared to the standard round.

b. To determine the approximate temperature at which cook-offs can be expected with the test cartridge.

2.5.2 Criteria

Misfire removal of the test round shall not require procedures which differ significantly from those in the present field manual.

2.5.3 Method

An 81-mm mortar was assembled with a thermocouple attached 36 inches from the muzzle of the tube. Sufficient control rounds were fired at charge 9 to heat the tube to +700°F. When this temperature was reached, a test round, at charge 9, less primer, was inserted in the tube. As a cook-off occurred, a second and then a third round was inserted. The temperature and elapsed time were recorded for each cook-off.

The test was repeated by again heating the tube to +700°F but this time the control round, less primer, was inserted.

The entire test was repeated by lowering the starting weapon temperatures in 100-degree increments until no cook-off occurred with either round.

2.5.4 Results

The test round cooked off in less time than the control round. Each time the test round cooked off it appeared to exit at full velocity as evidenced by the sound at launch. The control round, on the other hand, went a maximum of 75 feet. Each control round exited with the increment bags still burning and the powder continued to burn for several seconds on the ground.

The cook-off limiting temperature for the test round was erratic. One round inserted when the tube was at +550°F failed to cook-off whereas one inserted at a tube temperature of +527°F cooked off in 5 seconds. The tube temperature was raised to +532°F by this round and when the next round was immediately inserted, no cook-off resulted.

The lowest insertion temperature at which cook-off occurred with the cotton bag was +565°F.

2.5.5 Analysis

The significant outcome of this test is that the test bags cause a cook-off to exit at a velocity that appears to approach that of full ignition whereas the cotton bags fail to propel the round more than 75 feet. The advantage of the test bag is that a live round does not impact close to the mortar position; the disadvantage is that in attempting to remove a misfire before the tube has cooled, the round could cook-off at full velocity while the tube is being tilted to dump the round. So long as the procedures of the field manual (FM 23-90, January 1967) are followed, i.e., wait until the tube is cool enough to touch, there is no danger of a cook-off.

The apparent descrepancies in cook-off temperatures with the test bags may be due to the bags contacting the tube wall in some instances and not in others.

2.6 SEQUENTIAL ROUGH-HANDLING TEST

2.6.1 Objective

The objective was to determine if rough handling will adversely affect the test cartridge.

2.6.2 Criterion

The test cartridge shall withstand the rough handling and be safe to fire.

2.6.3 Method

The sequential rough handling was performed on the test and control cartridges following the outline shown in Figure 2.6-1, except that the control cartridges were tested at ambient temperature only (24 rounds).

Each test and control cartridge was inspected after each subtest in the rough-handling sequence and only those rounds successfully completing the sequence were fired at charge 9 for velocity data. A 10-round group of test cartridges which had not been subjected to rough handling was fired as a reference.

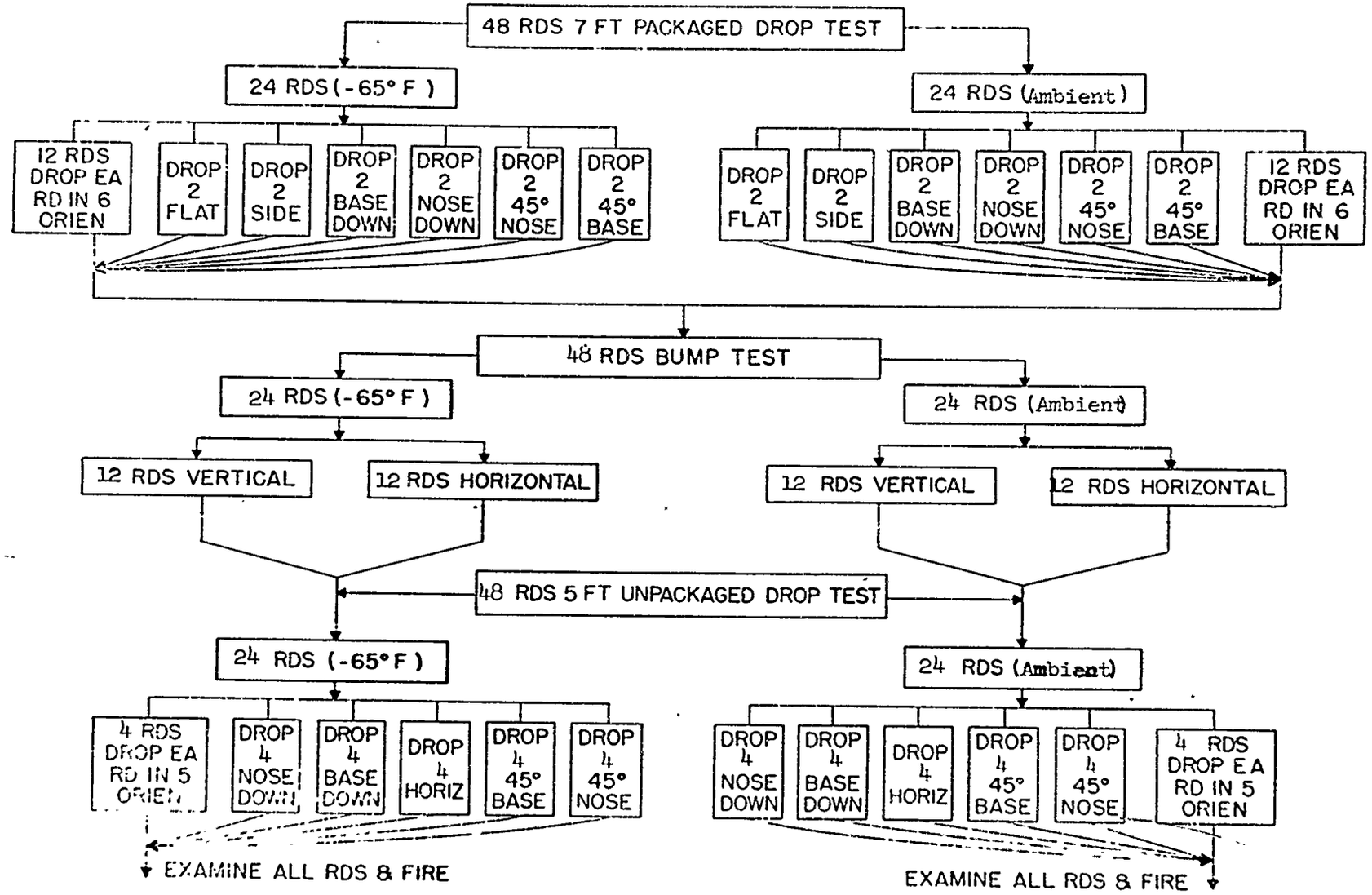


Figure 2.6-1: Rough-Handling Outline.

2.6.4 Results

The rough-handling results are summarized in Table 2.6-I.

Table 2.6-I. Summary of Results from Rough-Handling Test

	7-Foot Unpackaged Drop Test			Bump Test			5-Foot Unpackaged Drop Test		
	TC Amb Cond	TC -65°F	CC Amb Cond	TC Amb Cond	TC -65°F	CC Amb Cond	TC Amb Cond	TC -65°F	CC Amb Cond
Number of bags completely off.	6	0	0	7	0	0	5	4	0
Per cent of rounds with bags completely off.	8.3	0	0	8.3	0	0	16.6	12.5	0
Number of bags off at fin end only.	18	19	0	27	30	0	59	78	4
Per cent of rounds with bags off at fin end only.	29.2	25.0	0	45.8	29.2	0	66.7	75.0	16.6
Number of bags off at nose end only.	0	3	0	0	3	0	7	2	0
Per cent of rounds with bags off at nose end only.	0	8.3	0	0	8.3	0	25	8.3	0
Number of bags with ends ripped out.	1	2	0	0	0	0	1	1	0
Per cent of rounds with bags with ends ripped out.	4.2	4.2	0	0	0	0	4.2	4.2	0

Table 2.6-I (Cont'd)

	7-Foot Unpackaged Drop Test			Bump Test			5-Foot Unpackaged Drop Test		
	TC Amb Cond	TC -65°F	CC Amb Cond	TC Amb Cond	TC -65°F	CC Amb Cond	TC Amb Cond	TC -65°F	CC Amb Cond
Number of bags ripped open (propellant spilled).	0	0	0	1	6	0	1	2	0
Per cent of rounds with bags ripped open (propellant spilled).	0	0	0	4.2	16.6	0	4.2	8.3	0

TC = Test cartridge.
CC = Control cartridge.

Averages and standard deviations of muzzle velocity were calculated for all rounds fired and are summarized in Table 1.4-IV.

A test round was fired at charge 9 with a polystyrene muff purposely left on the round. This round had a muzzle velocity of 833 fps and a chamber pressure of 7400 psi.

2.6.5 Analysis

The test item failed to meet the criteria.

It was shown in tests conducted under TPR 784, USATECOM Project No. 8-9-3010-17 and TPR 690, USATECOM Project No. 8-9-3010-01 that the test increments will withstand the rough-handling sequence as well as the present cotton increments when the former are protected by a polystyrene muff.

It appears that extreme cold conditions cause the Celcon/silk increment to become brittle, and therefore, more apt to break open and spill propellant.

The round can be safely fired with the polystyrene muff left on. However, muzzle velocity and maximum chamber pressure will be lower than for the standard charge 9. Also, the rate of descent is slowed sufficiently to cause a misfire.

Two distinct velocity levels were noted when the test cartridges, subjected to rough handling, were fired. It is suspected that six cartridges were fired at charge 8 as the velocity levels for these six rounds were 814 and 816 fps at ambient temperature and 825 fps at +145°F.

2.7 TRANSPORTATION - VIBRATION TEST

2.7.1 Objective

The objective was to determine if transportation - vibration will adversely affect the test cartridge.

2.7.2 Criterion

The test cartridge shall withstand the transportation - vibration test and be safe to fire.

2.7.3 Method

Twenty-four inert test cartridges and 24 inert control cartridges were vibrated in accordance with MTP 4-2-804 (Interim Pamphlet 70-73) at ambient temperature only and in one plane. The cartridges were packaged as used in field shipment.

This test simulated a distance of 1000 miles in a 2-wheeled trailer and 3 hours in an aircraft.

All rounds were fired at charge 9 for velocity uniformity, and a 10-round group of test cartridges that was not subjected to vibration was used as a reference.

2.7.4 Results

None of the vibrated test cartridges or control cartridges was found to be damaged upon inspection.

Results of the velocity - uniformity firings are contained in Table 1.4-IV.

2.7.5 Analysis

The test criterion was met.

2.8 HUMAN FACTORS

2.8.1 Objective

The objective was to determine if any adverse human aspects are introduced into the system by the use of the waterproofed propellant system.

2.8.2 Criterion

No modification to the cartridge shall require additional training or changes to the training manual.

2.8.3 Method

Time trials for breaking down and reassembling ammunition were performed by personnel from the Infantry Board, Fort Benning, Georgia. Two military personnel having returned from combat duty as members of an 81-mm mortar squad performed this test.

After being briefed on the test requirements, each man removed five rounds of each type cartridge from the containers and broke the increments from charge 9 to charge 4. Then each man reassembled the rounds to charge 9 and placed the rounds in the containers. Two 5-round trials with each type round were conducted by each man.

Two times were recorded for each operation: the over-all time recorded from the instant the gunner grasped the container until the round was properly disassembled and the time required to disassemble the charges. Similarly, during reassembly the times were noted for reassembly of the charges and also until the round was replaced in the containers.

After a 1-day lapse, the entire sequence was repeated except that the rounds were torn down from charge 9 to charge 0 and reassembled.

All testing was conducted in a controlled-temperature magazine, and the rounds were placed on a work table to eliminate outside factors which would influence the results.

2.8.4 Results

A summary of disassembly and assembly times is contained in Table 1.4-IV. This table includes only the times required in removing or replacing the charges. Over-all times to unpack and repack the rounds are contained in the round-by-round data (Appendix I).

Slightly longer times were required to disassemble the test bags than the control bags. During reassembly, the times to prepare the test cartridges were markedly longer (as much as 75% longer) than those reacquired for the control round. This was true whether reassembling from charge 0 to 9 or charge 4 to 9.

2.8.5 Analysis

During each disassembly operation, care was taken to insure that the increment bags were not torn so they could be reassembled to the round. Nevertheless, some holes were enlarged or completely broken through. As a backup, the test increment bag is provided with two punched holes in each end to insure a means of fastening the charge to the round.

Several drawbacks were noted with the test bags. First, the holes in the ends were not cleanly punched out and were difficult to locate, especially if the hole appeared in the stencilled markings. Second, the holes were small and required extra manipulation to secure the bag to the tab on the increment holder. In order to prevent tearing of the bag, the hole had to be slipped over one wing on the tab, then the other. Third, there was no ability of the test bags to stretch in order to ease the alignment of the holes with the increment holder tabs.

The cotton bags, on the other hand, had large, clearly defined holes, and the bags had enough elasticity that they could be stretched to slip over the increment holder.

During this time trial, the test bags were used for only one teardown and reassembly. New rounds were used for each subsequent trial. The cotton bags were used for two trials with no noticeable wear. However, further use of the cotton bags would have enlarged the buttonholes and thereby biased the test.

The test personnel from Fort Benning indicated that there is very little likelihood that rounds which are broken down to a lower charge would have to be reassembled to the high charge. Thus, the longer assembly time required for the test bags does not present a problem in the field.

Although the times are longer, the method of assembly and disassembly does not require a change in training procedures.

2.9 REMOVAL OF MISFIRES

2.9.1 Objective

The objective was to determine if modifications applied to test rounds have changed misfire-removal procedures and if the degree of hazard has changed.

2.9.2 Criterion

The hazard of misfire removal for the test rounds shall not be greater than that for the standard M374 cartridge.

2.9.3 Method

During the cook-off test (paragraph 2.5) those rounds which did not cook-off after a sufficient waiting period were dumped.

Procedures for removing the rounds were observed.

2.9.4 Results

No changes in normal misfire removal were noted. The test round was easily removed from the weapon each time.

2.9.5 Analysis

In each instance, the danger of a cook-off had passed. Since the test round upon cook-off exits with apparent full velocity, in removing a misfire with this round sufficient time must be allowed to insure that the round will not cook-off. If the misfire-removal procedures of FM 23-90 are followed, no danger is introduced into the 81-mm mortar system by the test round.

2.10 MAINTENANCE EVALUATION

No maintenance problems were anticipated or encountered.

SECTION 3. APPENDICES

APPENDIX I - TEST DATA

Round-by-round data for residue, velocity-uniformity, transportation - vibration, and rough-handling tests are filed in the Mortar and Recoilless Rifle Branch, Materiel Test Directorate. These data will be retained for one year.

Waterproofness Test

Rd No.	Type Cartridge	Time Fired	Projectile Weight, lb	Velocity, fps	Remarks
			A. Puddle Test		
Date Fired: 2 May 1969. Mortar: M29E1, No. 9858. Test round 601 corresponds to tube round 5132. Weapon Elevation: 45°.					
			Charge 4		
601	Control	1325	9.13	525	
602	Control	1325	9.05	511	
603	Control	1326	9.16	452	
604	Control	1327	9.11	475	
605	Control	1328	9.13	146	-[a]
606	Control	1330	9.11	492	
607	Control	1331	9.10	229	-[a]
608	Control	NR	9.12	469	
609	Control	NR	9.11	375	
610	Control	NR	9.10	488	
Tube swabbed between groups.					
611	Test	NR	9.08	558	
612	Test	NR	9.20	518	
613	Test	NR	9.20	483	

[a]Tube swabbed following each extremely short round.

NR = Not recorded.

Rd No.	Type Cartridge	Time Fired	Projectile Weight, lb	Velocity, fps	Remarks
614	Test	NR	9.14	484	
615	Test	NR	9.10	519	
616	Test	NR	9.10	535	
617	Test	NR	9.18	527	
618	Test	NR	9.07	497	
619	Test	NR	9.16	549	
620	Test	NR	9.16	533	
621	Test	NR	9.22	524	
622	Test	NR	9.19	508	
623	Test	NR	9.21	526	
624	Test	NR	9.21	523	
625	Test	NR	9.20	533	

Tube swabbed between groups.

Charge 9

626	Control		[b] -	-[a]
627	Control		[b] -	-[a]
628	Dry control		879	
629	Test	9.10	766	
630	Test	9.20	[b] -	-[a]
631	Test	9.08	785	
632	Test	9.21	647	
633	Test	9.13	[b] -	-[a]
634	Test	9.26	796	
635	Test	9.18	[b] -	-[a]
636	Test	9.09	788	
637	Test	9.17	569	
638	Test	9.17	[b] -	-[a]
639	Test	9.18	617	
640	Test	9.10	750	
641	Test	9.12	720	
642	Test	9.20	[b] -	-[a]
643	Test	9.20	[b] -	-[a]
644	Dry control	-	879	

[a]Tube swabbed following each extremely short round.
[b]Velocities too low to be recorded.

NR = Not recorded.

Rd No.	Type Cartridge	Time Fired	Elapsed Drying Time, min	Projectile Weight, lb	Velocity, fps	Remarks
			B. Ten-Minute Immersion			
				Charge 4		
645	Control	1519	1	-	[b] -	Round went approximately 40 feet.
646	Control	1520	2	-	[b] -	Round went approximately 45 to 50 feet.
Test discontinued with control rounds.						
647	Test	1530	5	9.22	[b] -	-[a]
648	Test	1532	7	9.10	447	
649	Test	1533	8	9.12	200	-[a]
650	Test	1533	8+	9.20	[b]436	
651	Test	1534	9	9.21	[b] -	-[a]
652	Test	1535	10	9.18	519	
653	Test	1536	11	9.11	[b]369	
654	Test	1537	12	9.04	[b] -	-[a]
655	Test	1537	12+	9.20	528	
656	Test	1537	12+	9.18	473	
657	Test	1538	13	9.10	521	
658	Test	1538	13+	9.11	[b]541	
659	Test	1538	13+	9.12	[b] -	-[a]
660	Test	1539	14	9.14	541	
661	Test	1540	15	9.08	414	
Tube swabbed between groups.						
				Charge 9		
662	Test	1612	2	9.13	[b] -	-[a,c]
663	Test	1613	3	9.18	[b] -	-[a]
664	Test	1614	4	9.16	[b] -	-[a,c]
665	Test	1616	6	9.20	[b] -	-[a,d,e]
666	Test	1618	8	9.15	[b] -	-[a,e]
667	Dry control	1619	-	-	881	

[a]Tube swabbed following each extremely short round.
[b]Velocities too low to be recorded.
[c]Round went under second coil.
[d]Round hit first coil.
[e]Bags wiped with a dry rag.

Rd No.	Type Cartridge	Time Fired	Elapsed Drying Time, min	Projectile Weight, lb	Velocity, fps	Remarks
668	Test	1625	15	9.24	92	-[a]
669	Test	1626	16	9.10	51	-[a,f]
670	Test	1628	18	9.22	105	-[a]
671	Test	1639	29	9.23	843	
672	Test	1639	29+	9.22	854	
673	Test	1640	30	9.24	819	
674	Test	1640	30+	9.12	862	
675	Test	1640	30+	9.14	860	
676	Test	1641	31	9.04	859	
677	Test	1641	31+	9.18	859	

Tube swabbed between groups.

C. Two-Hour Immersion

Charge 4

678	Test	1803	3	9.22	[b] -	-[a]
679	Test	1804	4	9.08	90	-[a]
680	Test	1805	5	9.20	103	-[a]
681	Test	1806	6	9.10	88	-[a]
682	Test	1807	7	9.20	105	-[a]
683	Test	1807	7+	9.06	288	-[a]
684	Test	1808	8	9.06	110	-[a]
685	Test	1809	9	9.12	106	-[a]
686	Test	1810	10	9.20	141	-[a]
687	Test	1810	10+	9.04	449	-[a]
688	Test	1818	18	9.22	556	-[e,g]
689	Test	1819	19	9.08	539	
690	Test	1819	19+	9.10	571	-[e,g]
691	Test	1820	20	9.08	493	
692	Test	1821	21	9.20	390	-[e,g]

Tube swabbed between groups.

Charge 9

693	Test	1917	2	9.20	[b] -	-[a]
-	Test	1918	3	-	[b] -	Misfired on first attempt.[g]

[a]Tube swabbed following each extremely short round.
[b]Velocities too low to be recorded.
[e]Bags wiped with a dry rag.
[f]Round hit second coil.
[g]Tube dumped and swabbed.

Rd No.	Type Cartridge	Time Fired	Elapsed Drying Time, min	Projectile Weight, lb	Velocity, fps	Remarks
694	Test	1922	7	9.22	[b] -	Same round fired.[g]
695	Test	1924	9	9.16	[b] -	-[g]
696	Test	1932	17	9.19	[b] -	-[g]
697	Test	1934	19	9.08	[b] -	-[g]
698	Test	1945	30	9.12	[b] -	-[g]
699	Test	1950	35	9.06	94	-[a]
700	Test	1950	35+	9.06	[b] -	-[g]
701	Test	1955	40	9.20	[b] -	
702	Test	2006	51	9.12	672	
703	Test	2007	52	9.14	[b] -	-[a]
704	Test	2007	52+	9.12	84	-[a]
705	Test	2008	53	9.04	[b] -	-[a]
706	Test	2009	54	9.08	613	
707	Test	2010	55	9.16	72	

Tube swabbed at end of immersion test.

D. Ten-Minute Rain Test

Date Fired: 7 May 1969.

Charge 4

708	Test	1025	7	9.21	408
709	Test	1027	9	9.17	404
710	Test	1028	10	9.06	[b] -
711	Test	1030	12	9.18	339
712	Test	1031	13	9.14	156
713	Test	1032	14	9.19	440
714	Test	1033	15	9.08	491
715	Test	1034	16	9.21	497
716	Test	1035	17	9.12	513
717	Test	1036	18	9.16	398
718	Control	1038	20	9.11	250
719	Control	1038	20+	9.12	500
720	Control	1039	21	9.16	426
721	Control	1039	21+	9.16	456
722	Control	1040	22	9.09	[b] -

Tube dumped and swabbed between groups.

[a]Tube swabbed following each extremely short round.
[b]Velocities too low to be recorded.
[g]Tube dumped and swabbed.

Rd No.	Type Cartridge	Time Fired	Elapsed Drying Time, min	Projectile Weight, lb	Velocity, fps	Remarks
				Charge 9		
723	Test	1103	8	9.20	[b] -	
724	Test	1105	10	9.07	539	
725	Test	1106	11	9.19	[b] -	-a,f
726	Test	1108	13	9.21	[b] -	-a
727	Test	1110	15	9.15	818	
728	Test	1111	16	9.22	505	
729	Test	1112	17	9.06	819	
730	Test	1113	18	9.06	301	
731	Test	1115	20	9.21	[b] -	-a
732	Test	1118	23	9.23	826	
733	Control	1120	25	-	[b] -	-a
734	Control	1120	25	-	[b] -	-a,f
735	Control	1121	26	-	NT	-a,f
736	Control	1122	27	-	NT	Round went approximately 100 yards.[a]
737	Control	1123	28	-	NT	

Tube swabbed between groups.

E. Half-Hour Rain Test

Charge 4

738	Test	1343	8	9.06	541
739	Test	1344	9	9.16	515
740	Test	1345	10	9.14	468
741	Test	1345	10+	9.10	298
742	Test	1346	11	9.12	502
743	Test	1347	12	9.18	539
744	Test	1348	13	9.16	494
745	Test	1349	14	9.19	534
746	Test	1350	15	9.18	543
747	Test	1350	15+	9.12	545
748	Control	1352	17	9.06	542
749	Control	1352	17+	9.14	387
750	Control	1352	17+	9.04	370

[a]Tube swabbed following each extremely short round.
[b]Velocities too low to be recorded.
[f]Round hit second coil.

NT = Not taken.

Rd No.	Type Cartridge	Time Fired	Elapsed Drying Time, min	Projectile Weight, lb	Velocity, fps	Remarks
751	Control	1353	18	9.18	284	
752	Control	1353	18+	9.16	358	
			F. Two-Hour Rain Test			
			Charge 4			
753	Test	1407	7	9.10	309	
754	Test	1408 to 1412	12	9.08	551	
755	Test	1413	13	9.18	232	
756	Test	1414	14	9.08	461	
757	Test	1415	15	9.18	[b] -	[a]
758	Test	1417	17	9.06	259	
759	Test	1418	18	9.14	261	
760	Test	1419	19	9.06	448	
761	Test	1419	19+	9.04	363	
762	Test	1420	20	9.08	503	
763	Control	1422	22	9.13	126	
764	Control	1422	22+	9.13	[b] -	
765	Control	1423	23	-	418	[h]
766	Control	1424	24	9.10	[b] -	
767	Control	1424	24+	9.10	242	
			G. Half-Hour Rain Test			
			Charge 9			
768	Test	1512	7	9.16	[b] -	Round tumbled, went approximately 75 yards.
769	Test	1513	8	9.11	[b] -	[f]
770	Test	1514	9	9.23	806	
771	Test	1515	10	9.25	432	
772	Test	1516	11	9.15	[b] -	Round went approximately 75 yards.[a]
773	Test	1517	12	9.15	[b] -	Round went approximately 60 yards.[f]

[a]Tube swabbed following each extremely short round.
[b]Velocities too low to be recorded.
[f]Round hit second coil.
[h]Round 765 was subject to the rain test as a charge 9 and broken to charge 4 prior to firing.

Rd No.	Type Cartridge	Time Fired	Elapsed Drying Time, min	Projectile Weight, lb	Velocity, fps	Remarks
774	Test	1522	17	9.22	686	
775	Test	1522	17+	9.18	538	
776	Test	1523	18	9.24	802	
777	Control	1524	19	-	[b] -	-[a,f]
778	Control	1524	19+	-	NT	Round went approximately 75 yards.
779	Control	1524	19+	-	NT	Same as round 778.
780	Control	1524	19+	-	NT	Same as round 778.
781	Control	1525	20	-	NT	Round went approximately 300 yards.

H. Two-Hour Rain Test

Charge 9

782	Test	1554	14+	9.15	[b] -	-[a,f]
783	Test	1555	15	9.12	[b] -	Same as round 778.[a]
784	Test	1556	16	9.24	127	Round went approximately 150 yards.[a]
785	Test	1556	16+	9.14	[b] -	Round went approximately 75 yards.[a]
786	Test	1557	17	9.12	[b] -	Round went approximately 60 yards.[a]
787	Test	1558	18	9.24	[b] -	Same as round 786.[a]
788	Test	1559	19	9.24	[b] -	-[a,f]
789	Test	1600	20	9.20	685	-[e]
790	Test	1601	21	9.18	841	-[e]
791	Test	1601	21	9.08	[b] -	-[a,f]
792	Control	1602	22	9.18	[b] -	-[a,c]
793	Control	1602	22+	9.06	[b] -	-[a,c]
794	Control	1604	24	9.18	[b] -	-[a,f]
795	Control	1604	24+	-	[b] -	-[a,c]
796	Control	1604	24+	-	[b] -	-[a,c]

[a]Tube swabbed following each extremely short round.
[b]Velocities too low to be recorded.
[c]Round went under second coil.
[e]Bags wiped with a dry rag.
[f]Round hit second coil.

NT = Not taken.

Cook-Off Test

Date Fired: 16 May 1969.
Mortar: M29, No. 9858.
Test round 1 corresponds to tube round 5493.

Round No. Test	Round No. Total	Time Fired	Type Ctg	Weapon Temp, °F At Start	Weapon Temp, °F At Insertion	Weapon Temp, °F At Cook-Off	Time to Cook-Off, sec	Remarks
Nominal Temperature: +700°F.								
1 thru 30	797 thru 826	0949	Warmers	65	-	-	-	
31	827		Test	-	705	685	13	Apparent full velocity.
32	828		Test	-	690	680	8	Apparent full velocity.
33	829		Test	-	682	660	13	Apparent full velocity.
34 thru 44	830 thru 840	0952	Warmers	540	-	-	-	
45	841		Control	-	712	675	22	Round went approximately 40 feet.
46	842		Control	-	675	575	47	Round went approximately 62 feet.
47	843		Control	-	575	505	38	Round went approximately 32 feet.
Nominal Temperature: +600°F.								
48 thru 66	844 thru 862	1005	Warmers	228	-	-	-	
67	863		Test	-	610	600	12	Apparent full velocity.
68	864		Test	-	605	545	43	Apparent full velocity.
69	865		Test	-	550		[a] -	Round dumped after 13 minutes at +140°F.

[a]Did not cook-off.

Round No. Test	Round No. Total	Time Fired	Type Ctg	Weapon Temp, °F At Start	Weapon Temp, °F At Insertion	Weapon Temp, °F At Cook-Off	Time to Cook-Off, sec	Remarks
70 thru 93	866 thru 889	1021	Warmers	130	-	-	-	
94	890		Control	-	628	565	38	Round went approximately 75 feet.
95	891		Control	-	565	440	89	Round went approximately 75 feet.
96	892		Control	-	435		[a] -	Round dumped after 12 minutes at +125°F.
Nominal Temperature: +500°F.								
97 thru 116	893 thru 912	1045	Warmers	95	-	-	-	
117	913		Test	-	527	525	5	Apparent full velocity.
118	914		Test	-	532		[a] -	Round dumped after 10 minutes at +150°F.
Nominal Temperature: +400°F.								
119 thru 132	915 thru 928	1104	Warmers	95	-	-	-	
133	929		Test	-	415		[a] -	Round dumped after 10 minutes at +150°F.
Nominal Temperature: +500°F.								
134 thru 152	930 thru 948	1118	Warmers	120	-	-	-	
153	949		Control	-	535		[a] -	Round dumped after 10 minutes at +175°F.

[a]Did not cook-off.

See notes on following page.

Notes: Warmer rounds were control rounds which were rapid-fired to heat the tube to the desired temperature.
Velocities were not recorded. The sound of the test rounds at cook-off appeared to be that of a charge 9 round fired normally (cook-off rounds had no primers).

Human-Factors Test

Gunner	Operation	Time[a], seconds Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Date Conducted: 6 May 1969.						
		Group I				
		Cotton Bags				
A	Charge 9 to 4	34, 27	26, 21	24, 18.5	23, 17	21, 16
	Charge 4 to 9	50, 38	47, 43	35, 32.5	33, 30	46, 43
B	Charge 9 to 4	19, 12.5	17, 12	18, 12	17, 11	18, 12.5
	Charge 4 to 9	54, 49	50, 46.5	33, 29.5	42, 38.5	30, 25
		Celcon/Silk Bags				
A	Charge 9 to 4	28, 25	27, 24.5	26, 22.5	16, 14	18, 16
	Charge 4 to 9	51, 49	43, 41	[b] -	70, 69	44, 43
B	Charge 9 to 4	21, 18.5	21, 16.5	16, 14	18, 15	16, 13.5
	Charge 4 to 9	78, 75	60, 57	73, 66	60, 57.5	60, 55.5
		Group II				
		Cotton Bags				
B	Charge 9 to 4	17, 12	16, 10.5	18, 14	15, 10.5	14, 9.5
	Charge 4 to 9	30, 27	34, 32	29, 26	29, 25.5	31, 27

[a]The first number in each column indicates total time to remove round from container and strip charges (or reassemble charges and replace round in container). The second figure indicates the time required to disassemble or reassemble the increment charges.
[b]Hole torn in end of one bag; could not be assembled to round.

Gunner	Operation	Time[a], seconds Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
A	Charge 9 to 4	18, 13.5	15, 11	16, 12	16, 11	16, 11
	Charge 4 to 9	30, 26	36, 34	40, 37.5	29, 26	32, 29.5
		Celcon/Silk Bags				
B	Charge 9 to 4	18, 14.5	15, 13	20, 18	12, 9.5	14, 11.5
	Charge 4 to 9	43, 38.5	49, 46	50, 48	58, 56	48, 45
A	Charge 9 to 4	15, 12	16, 12	14, 11	16, 13.5	14, 11.5
	Charge 4 to 9	65, 63	45, 42.5	60, 57	62, 60	45, 41
		Group III				
		Celcon/Silk Bags				
A	Charge 9 to 0	26, 22.5	22, 20	28, 26.5	24, 21.5	28, 25.5
	Charge 0 to 9	88, 84.5	93, 91	97, 93.5	82, 79.5	82, 79
B	Charge 9 to 0	26, 23	24, 20.5	25, 22	21, 18.5	20, 18.5
	Charge 0 to 9	96, 94.5	115, [c] 111	87, 85	99, 96	88, 86
		Cotton Bags				
A	Charge 9 to 0	25, 23	20, 17	24, 21.5	22, 20	20, 18.5
	Charge 0 to 9	59, 56	57, 55	61, 59.5	68, 63.5	55, 53
B	Charge 9 to 0	25, 21	20, 17.5	24, 22.5	17, 15	22, 20
	Charge 0 to 9	58, 56	68, 66	67, 64	62, 60	54, 51.5

[a]The first number in each column indicates total time to remove round from container and strip charges (or reassemble charges and replace round in container). The second figure indicates the time required to disassemble or reassemble the increment charges.

[c]"A" bag had been wrapped loosely around boom making installation of "B" bags difficult.

Gunner	Operation	Time[a], seconds Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
		Cotton Bags				
B	Charge 9 to 0	19, 17	21, 19	18, 15	18, 15.5	20, 17.5
	Charge 0 to 9	57, 54.5	52, 50.5	53, 50.5	52, 50	55, 53.5
A	Charge 9 to 0	17, 15	18, 15.5	21, 18.5	18, 15	23, 21
	Charge 0 to 9	49, 47	50, 54.5	56, 54	57, 54	70, 68
		Celcon/Silk Bags				
B	Charge 9 to 0	28, 22.5	25, 23	31, 28	29, 26.5	20, 17
	Charge 0 to 9	89, 86.5	80, 77.5	89, 87	112, 109	82, 80
A	Charge 9 to 0	35, 33	26, 23	22, 19.5	32, 29.5	27, 24
	Charge 0 to 9	75, 72	108, 105	113, 110	83, 80	97, 94.5

[a]The first number in each column indicates total time to remove round from container and strip charges (or reassemble charges and replace round in container). The second figure indicates the time required to disassemble or reassemble the increment charges.

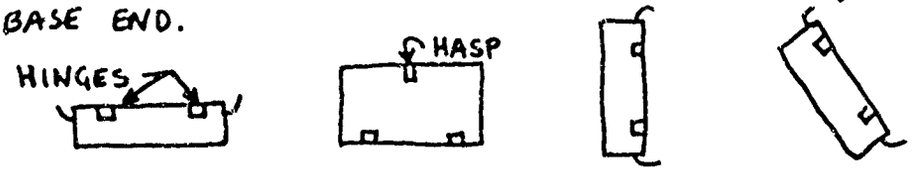
ROUND BY ROUND DATA 14 MAY 1969

OBJECT OF TEST: PACKAGED SEVEN-FOOT DROP TEST OF CTG 81MM, M374 (AMBIENT TEMPERATURE)

ROUND No.	ORIENTATION		RESULTS (REFER TO "DAMAGE CODE")				
C-1	MULTIPLE DROPS[a]		NO VISIBLE DAMAGE				
2	"	"	"	"	"		
3	"	"	"	"	"		
4	"	"	"	"	"		
5	"	"	"	"	"		
6	"	"	"	"	"		
T-25	"	"	1A				
26	"	"	2A, 3C, 1D				
27	"	"	6A				
28	"	"	1A				
29	"	"	1A				
30	"	"	5A, 3C				
C-7	45° BASE DOWN		NO VISIBLE DAMAGE				
8	"	"	"	"	"		
9	"	"	"	"	"		
T-46	"	"	"	"	"		
47	"	"	"	"	"		
48	"	"	"	"	"		
C-10	HORIZONTAL		"	"	"		
11	"		"	"	"		
12	"		"	"	"		
T-31	"		"	"	"		
32	"		1A				
33	"		NO VISIBLE DAMAGE				
C-13	HINGE SIDE		" "		"		
14	"	"	" "		"		
15	"	"	" "		"		
T-34	"	"	" "		"		
35	"	"	" "		"		
36	"	"	1A				

REMARKS:

[a] SIX ORIENTATIONS: FLAT ON BOTTOM OF BOX, NOSE END, BASE END, HINGE SIDE, 45° TO NOSE END, 45° TO BASE END.



HORIZONTAL HINGE SIDE NOSE DOWN 45° NOSE DN

ROUND BY ROUND DATA

OBJECT OF TEST:

C-16	BASE DOWN		NO VISIBLE DAMAGE				
17	"	"	"	"	"		
18	"	"	"	"	"		
T-37	"	"	"	"	"		
38	"	"	"	"	"		
39	"	"	"	"	"		
C-19	NOSE DOWN		"	"	"		
20	"	"	"	"	"		
21	"	"	"	"	"		
T-40	"	"	"	"	"		
41	"	"	"	"	"		
42	"	"	"	"	"		
C-22	45° NOSE DOWN		"	"	"		
23	"	"	"	"	"		
24	"	"	"	"	"		
T-43	"	"	"	"	"		
44	"	"	"	"	"		
45	"	"	"	"	"		

REMARKS:

STEAP DS Form 208, 3 Jan 66

ROUND BY ROUND DATA 15 MAY

OBJECT OF TEST: PACKAGED SEVEN-FOOT DROP TEST OF CTG, 81 MM, M374 (-65°F)

ROUND NO.	ORIENTATION	RESULTS (REFER TO "DAMAGE CODE")
T-1[b]	MULTIPLE DROPS[a]	NO VISIBLE DAMAGE
2[b]		" " "
3[b]		" " "
4[b]		" " "
5[b]		" " "
6[b]		" " "
T-7	45° BASE DOWN	" " "
8		" " "
9		" " "
T-10[b]	HORIZONTAL	" " "
11[b]		" " "
12[b]		" " "
T-13[b]	HINGE SIDE	" " "
14[b]		" " "
15		1A
T-16	BASE DOWN	NO VISIBLE DAMAGE
17[b]		" " "
18		" " "
T-19	NOSE DOWN	" " "
20		5A
21		3A
T-22	45° NOSE DOWN	NO VISIBLE DAMAGE
23		" " "
24		" " "

REMARKS:

[a] SIX ORIENTATIONS

[b] BLACK PLASTIC BAG OVER INCREMENTS TORN

WATERPROOFING WAX EMBRITTLED AND FLAKED OFF FIBER CONTAINERS

STEAP DS Form 208, 3 Jan 66

ROUND BY ROUND DATA

OBJECT OF TEST: UNPACKAGED FIVE-FOOT DROP TEST OF CTG, 81MM, M374 (−65° F)

ROUND No.	ORIENTATION	INCREMENTS REMAINING	RESULTS (REFER TO "DAMAGE CODE")
T-19	NOSE DOWN	8	1A
13	" "	7	2A
10	" "	8	4A, 1SA
16	" "	7	NO VISIBLE DAMAGE
T-18	BASE DOWN	8	1A
9	" "	8	NO VISIBLE DAMAGE
12	" "	8	1A, 1B
15	" "	7	4A
T-17	HORIZONTAL	8	3A
11	"	8	3A 1C 1SA
8	"	8	4A
14	"	8	1J, 3A
T-1	45° BASE DOWN	8	3A
4	" " "	5	5A
7	" " "	8	NO VISIBLE DAMAGE
20	" " "	6	2A
T-2	45° NOSE DOWN	7	7A
5	" " "	4	1A, 1C 1SA
21	" " "	8	4A, 1SA°
23	" " "	8	1A
T-3	NOSE DOWN	5	NO VISIBLE DAMAGE
6	" "	3	3A
22	" "	8	NO VISIBLE DAMAGE
24	" "	8	" " "
T 3	BASE DOWN	5	2A
6	" "	3	3A, 1D
22	" "	8	2A, 1J
24	" "	8	2A, 1B

REMARKS:

°SPIRAL INCREMENT, TORN EYELET AT NOSE END

STEAP DS Form 208, 3 Jan 66

ROUND BY ROUND DATA

OBJECT OF TEST:

T-3	HORIZONTAL		3	1A			
6	"		1	1A			
22	"		5	1A			
24	"		5	4A			
T-3	45° BASE DOWN		3	1SA			
6	"	" "	0	NO VISIBLE DAMAGE			
22	"	" "	5	2A			
24	"	" "	3	2C			
T-3	45° NOSE DOWN		3	1A			
6	" "	"	0	NO VISIBLE DAMAGE			
22	" "	"	3	1A			
24	" "	"	1	1A			

REMARKS:

STEAP DS Form 208, 3 Jan 66

ROUND BY ROUND DATA

OBJECT OF TEST: UNPACKAGED FIVE-FOOT DROP TEST OF CTG, 81MM, M374 (-65° F)

ROUND No.	ORIENTATION	INCREMENTS REMAINING	RESULTS (REFER TO "DAMAGE CODE")
T-19	NOSE DOWN	8	1A
13	" "	7	2A
10	" "	8	4A, 1SA
16	" "	7	NO VISIBLE DAMAGE
T-18	BASE DOWN	8	1A
9	" "	8	NO VISIBLE DAMAGE
12	" "	8	1A, 1B
15	" "	70	4A
T-17	HORIZONTAL	8	3A
11	"	8	3A 1C 1SA
8	"	8	4A
14	"	8	1J, 3A
T-1	45° BASE DOWN	8	3A
4	" " "	5	5A
7	" " "	8	NO VISIBLE DAMAGE
20	" " "	6	2A
T-2	45° NOSE DOWN	7	7A
5	" " "	4	1A, 1C, 1SA
21	" " "	8	4A, 1SA°
23	" " "	8	1A
T-3	NOSE DOWN	5	NO VISIBLE DAMAGE
6	" "	3	3A
22	" "	8	NO VISIBLE DAMAGE
24	" "	8	" " "
T 3	BASE DOWN	5	2A
6	" "	3	5A, 1D
22	" "	8	2A, 1J
24	" "	8	2A, 1B

REMARKS:

°SPIRAL INCREMENT, TORN EYELET AT NOSE END

STEAP DS Form 208, 3 Jan 66

ROUND BY ROUND DATA 24 MAY

OBJECT OF TEST: UNPACKAGED FIVE-FOOT DROP TEST OF CTG, 81 MM, M374 (AMBIENT TEMPERATURE)

ROUND No.	ORIENTATION	INCREMENTS REMAINING[a]	RESULTS (REFER TO "DAMAGE CODE")
C-19	NOSE DOWN	8	NO VISIBLE DAMAGE
C-10	" "	8	NO VISIBLE DAMAGE
C-13	" "	8	" " "
C-16	" "	8	" " "
C-18	BASE DOWN	8	" " "
9	" "	8	" " "
12	" "	8	" " "
15	" "	8	" " "
C-17	HORIZONTAL	8	" " "
8	"	8	1A
11	"	8	NO VISIBLE DAMAGE
14	"	8	" " "
C-1	45° BASE	8	1A
4	"	8	NO VISIBLE DAMAGE
7	"	8	" " "
20	"	8	" " "
C-2	45° NOSE	8	" " "
5	"	8	" " "
21	"	8	" " "
23	"	8	" " "
C-3	NOSE DOWN	8	" " "
6	" "	8	" " "
22	" "	8	" " "
24	" "	8	" " "
C-3	BASE DOWN	8	" " "
6	" "	8	" " "
22	" "	8	" " "
24	" "	8	" " "

REMARKS:

[a] VERTICAL INCREMENTS, BEFORE DROPPING

STEAP DS Form 208, 3 Jan 68

ROUND BY ROUND DATA 24 MAY

OBJECT OF TEST:

C-3	HORIZONTAL		8	NO VISIBLE DAMAGE			
6	"		8	"	"	"	
22	"		8	"	"	"	
24	"		8	"	"	"	
C-3	45° BASE DOWN		8	"	"	"	
6	" "	"	8	1A			
22	" "	"	8	NO VISIBLE DAMAGE			
24	" "	"	8	"	"	"	
C-3	45° NOSE DOWN		8	1A			
6	" "	"	8	NO VISIBLE DAMAGE			
22	" "	"	8	"	"	"	
24	" "	"	8	"	"	"	
T-43	NOSE DOWN		8	"	"	"	
34	"	"	8	1A			
37	"	"	8	2A			
40	"	"	8	NO VISIBLE DAMAGE			
T-42	BASE DOWN		7	3A			
33	"	"	8	2A, 2B			
36	"	"	6	1A			
39	"	"	8	1A, 1B			
T-41	HORIZONTAL		8	2A			
32	"		8	3A			
35	"		8	NO VISIBLE DAMAGE			
38	"		8	3A, 1C, 1SA			
T-25	45° BASE DOWN		8	8A			
31	" "	"	8	NO VISIBLE DAMAGE			
28	" "	"	7	3A, 1D			
44	" "	"	8	5A			

REMARKS:

STEAP DS Form 208, 3 Jan 66

ROUND BY ROUND DATA 24 MAY

OBJECT OF TEST:

T-26	45° NOSE DOWN		3	3A, 1SB			
29	" "	"	6	3A			
45	" "	"	8	5A, 2C			
47	" "	"	8	3A			
T-27	NOSE DOWN		2	NO VISIBLE DAMAGE			
30	"	"	0	NOT DROPPED			
46	"	"	8	1A			
48	"	"	8	NO VISIBLE DAMAGE			
T-27	BASE DOWN		2	NO VISIBLE DAMAGE			
30	"	"	0	NOT DROPPED			
46	"	"	8	NO VISIBLE DAMAGE			
48	"	"	8	1C, 1J			
T-27	HORIZONTAL		2	1SB			
30	"		0	NOT DROPPED			
46	"		8	NO VISIBLE DAMAGE			
48	"		7	1B			
T-27	45° BASE DN		2	1A, 1SC			
30	" "	"	0	NOT DROPPED			
46	" "	"	8	3A			
48	" "	"	6	3A, 1B, 1SA			
T-27	45° NOSE DOWN		1	NOT DROPPED			
30	" "	"	0	NOT DROPPED			
46	" "	"	5	4A, 1SB			
48	" "	"	1	NO VISIBLE DAMAGE			

REMARKS:

ROUND-BY-ROUND DATA

"DAMAGE CODE" FOR EXPERIMENTAL INCREMENT BAGS

CODE	DESCRIPTION OF DAMAGE
A	VERTICAL INCREMENT DETACHED AT FIN END ONLY
B	" " " " NOSE " "
C	" " " COMPLETELY
D	" " TORN AT NOSE END (NOT DETACHED)
E	" " " " FIN " " "
SA	SPIRAL " DETACHED AT FIN END ONLY
SB	" " " " NOSE " "
SC	" " " COMPLETELY
J	INCREMENT TORN; PROPELLANT SPILLED

STEAP-MT FORM 208, 19 Dec 68 (Rev) (Previous edition may be used)

DEPARTMENT OF DEFENSE AMMUNITION DATA CARD	FORM APPROVED BUDGET BUREAU NO. 22-R0269	LOT NUMBER MA-SP-812A

ITEM NOMENCLATURE	FSN	PACKING OF LOT
Cartridge, 81MM, Inert Loaded, M374 W/Empty Fuze, P.D., M52A5 F/Mortars M1 and M29	N/A	See Note 2
MANUFACTURING, LOADING OR ASSEMBLING ACTIVITY [illegible] ARMY AMMUNITION PLANT	NET QUANTITY 1,512	

CONTRACTOR	CONTRACT OR ORDER NO.	DRAWING OR REVISION	SPECIFICATION & REVISION
[illegible] SALES, INC.	DA-11-173-AMC-520(A)	8881026 (ref)	See Note 1

DATE STARTED	DATE COMPLETED	DATE INSPECTED	LOT	ZONE WT SHELL
4-19-69	4-19-69	4-19-69	C	

CHARGE WEIGHT	INDEX OF POWDER	MPD IN INCHES	PPDR IN INCHES

EXPLOSIVE WT PER PKG	EXPECTED MUZZLE VELOCITY	EXPECTED PRESSURE	SHELL WEIGHT
			9.18 lbs.

NUMBER OF TEST SAMPLES	SENT TO	DATE AND MODE OF SHIPMENT

COMPONENTS (CONTINUE ON REVERSE, IF NECESSARY)

COMPONENTS	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG	LOT NO.	QUANTITY
Projectile Metal Parts	10520202/Unk	M374	Frankford Arsenal	1969	FA-E-531	1,278
					FA-E-533	234
Ring, Obturating	10534925		Reo Plastics, Inc.	1969	REO-3-13	1,512
Filler "E" Consisting of:						
Glyceride of 12 Hydroxy Stearic Acid	PA-PD-721		Harchem Division of Wallace & Tiarman	Unk.	1260	

DISPOSITION	TYPED NAME OF GOVERNMENT INSPECTOR
ACCEPTED	for MALCOLM INGRAM
	SIGNATURE Sidney Bynum 4-21-69

AD FORM 6520, 1 FEBRUARY 1968

COMPONENT (CONT' FROM FRONT)	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG	LOT NO.	QUANTITY
Filler "E" (cont'd)						
Gypsum, Dead Burned	PA-PD-722		U. S. Gypsum Co.	Unk.	Unk.	
Rosin	LLL-R-626B		Pittsburgh Plate Glass	Unk.	Unk.	
Liner	7549011/4		Anaconda American Brass	1968	AAB-38-14	
Pin Assembly	10520200/G	M149	Stewart Warner Corp.	1969	SW-2-35	
Cartridge, Ignition	9233373	M66E1	Security Signals, Inc.	1969	SOK-8-53	
Pressure Plate	9218640/1		FTS Corp.	1969	FTS-14-6	
Increment Holder, Front	7549026/Unk		Hunter Spring	1969	HS-4-4	
Fuze, P.D.	9205729/ref.	Inert M52A5	Milan Army Ammo Plant	1969	None	
Increment, Propellant Chg. A	8881021/Unk	M90	Indiana Ord. Plant	1969	IND-18-6	432
Increment, Propellant Chg. B	8881023/Unk	M90	Indiana Ord. Plant	1969	IND-18-7	3,456
Primer, Percussion	7549173/G	M71A1E1	Milan Army Ammo Plant	1969	MA-2-27	
Label, Warning	7549014/3		U. S. Tape & Label Co.	1969	None	
Bag, Protective Ass'y	9229185		Crystal-X Corp.	1969	None	432
Tape, Filament	MIL-T-43036A		3M Corp.	1969	None	
Stop, Packing	8838116/3		Eastern Tool & Mfg. Co.	1969	ETM-30-2	
Container, Ammo, Fiber	9230175	M52A3	R. C. Can Co.	1969	RCN-Mix	
Bag, Desiccant	8790670	Type 2	Eagle Chemical Co.	1969	None	432
Sheet, Plastic	SPEC-LP-378		Monsanto Corp.	1969	None	
Box, Wood, Packing	9230176/B		Bilt-Rite Box Co.	1968	None	260
			Miller Box Co.	1968	None	244

(MA-SP-812A, M374)

(CONTINUED ON ATTACHED CARD)

COMPONENT (CONT' FROM FRONT)	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG.	LOT NO.	QUANTITY

(MA-SP-812A)

REMARKS: (SYMBOLS: *CHANGES IN PROCESS: **DEVIATIONS FROM DWG. OR SPEC: ***UNUSUAL OCCURRENCES OR DIFFICULTIES)

1. MIL-C-46995B (MU) W/A1, W/E.O.'s 49098-2, 48890-2, 50071-2, 49281-2, 49611-2, 51345-2, 51033-2, 54444-2, 54033-2, 54825-2, W/Msg. R-02-69-278, W/TT E.O. 53711-2.
2. Four hundred thirty-two (432) rounds were assembled with increment and were jungle packed; the remaining 1,080 rounds were assembled with zero increments and were not jungle packed.
3. This lot inert loaded, assembled, and packed as directed by tel con Mr. Neal, APSA, and Mr. Oates, MAAP, 4-15-69, Reg. PA-TT-4-0617 dtd 9 Apr 69, and SMUAP-AMM MA-39-69 ltr dtd 4-15-69 signed Quenzler.

APPENDIX III - CORRESPONDENCE

COPY/vr

DEPARTMENT OF THE ARMY
HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

S - 7 Mar 1969

AMSTE-BC

3 Mar 1969

SUBJECT: Directive for Product Improvement Test of Cartridge, 81-MM, HE, M374 with Reduced Bourrelet and Waterproofed Ignition/ Propellant System, USATECOM Project No. 8-9-3010-20

Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-CO-P
APG, Maryland 21005

1. Reference: Message, AMCPM-MT 02-0594 for AMSTE-BC, 12 Feb 1969, subject: Independent USATECOM Evaluation of Product Improved 81-MM M374 Cartridge, Inclosure 1.

2. Background: Currently, Cartridge, 81-MM, HE, M374 and its WP counterpart, M375, does not feature a waterproof ignition/propellant system. As a result, short rounds and misfires have been encountered in the field when these cartridges have been exposed to excessive moisture. As an interim solution relative to moisture protection, 81-mm mortar ammuntion is currently supplied to the field in a fiber container, which in turn is "Jungle Wrapped." As the section of the cartridge containing the ignition/propelling charge is protected by a waterproof barrier bag, the cartridge can be removed from its shipping container and still be waterproof, however, once the barrier bag is removed the item is again susceptible to moisture contamination. Because of ammunition preparation requirements at combat mortar positions, this is undesirable. Picatinny Arsenal has been tasked to develop a moisture resistant ignition/propellant system for use with current 81-mm mortar ammunition. Waterproofing of components has resulted in an acceptable ignition system; testing of a waterproof propelling charge is currently underway at APG and is expected to provide sufficient data upon which a choice of propelling bag materiel can be made. This command has been tasked by AMCPM-MT to conduct an independent evaluation of the final waterproof design and submit conclusions relative to item suitability for US Army use.

3. Description of Materiel: The test item will feature the Cartridge, 81-MM, M374 with a reduced bourrelet; an ignition cartridge container with 24 - 0.125 inch flash holed; a 108 grain mylar wrapped ignition cartridge

without brass liner and a primer with sealant applied to the primer threads. The final selection of a waterproof propellant bag materiel has not yet been made, however, current testing favors use of a celcon/ silk bag materiel.

4. Test Objectives:

a. To determine if the waterproofed ignition/propellant system will provide sufficient protection against moisture to eliminate or significantly reduce field problems with short rounds.

b. To determine if performance characteristics in temperature extremes, of pressure, velocity, range, accuracy, signature, etc., are affected by the waterproofed ignition/propellant system and the bourrelet reduction.

c. To assure that no safety or human factors problems have been induced into the system.

d. To determine suitability for US Army use as an alternate for the current standard cartridge.

5. Responsibilities: Aberdeen Proving Ground will:

a. Review and analyze all data from previous tests at Picatinny Arsenal and at Aberdeen Proving Ground.

b. Prepare a formal test plan in accordance with USATECOM Regulation 705-2 that will satisfy the objectives of paragraph 4.

c. Conduct the Product Improvement Test, prepare the final report, and provide this headquarters with a recommended USATECOM position relative to suitability for US Army use of the waterproofed ignition/ propellant system as an alternate for the current standard system.

d. Prepare an Initial Production Test Plan to satisfy the requirements of AMC Regulation 700-34 and forward this plan through this headquarters to Picatinny Arsenal for concurrence, approval and assignment. The Initial Production Test will be assigned a separate USATECOM project number upon receipt of a test request from Picatinny Arsenal.

6. Coordination: Aberdeen Proving Ground is to coordinate the Initial Production Test Plan with Picatinny Arsenal.

7. Special Instructions:

a. USATECOM Project No. 8-9-3010-20 is assigned as per STE Form 1028, Inclosure 2.

b. If actual or potential human factors problems can be associated with the test ammunition, i.e., loading, rate of fire, handling of charges, etc., they should be discussed with the US Army Infantry Board, and if deemed necessary, additional tests will be imposed with the participation of the USAIB to resolve mutual concerns. The degree of participation of the USAIB is to be resolved at an early date and this headquarters is to be advised accordingly so as to permit direction to USAIB as deemed necessary.

c. Aberdeen Proving Ground is to submit funding requirements to this headquarters.

d. APG recommendations will not be included in the test report, but will be forwarded this headquarters under separate cover.

8. Test Plans and Reports:

a. Aberdeen Proving Ground will submit 10 copies of the formal test plan as stated in paragraph 5b to this headquarters no later than 7 March 1969.

b. A final test report will be prepared in accordance with USATECOM Regulation 705-2 and 30 copies will be forwarded to this headquarters for approval and distribution.

c. As per paragraph 5d, an Initial Production Test Plan will be prepared by Aberdeen Proving Ground. A complete formal test plan is not required, but Section 2, "Details of Test" of USATECOM Regulation 705-2 should be included as a minimum.

9. Safety: Sufficient testing should be conducted to provide assurance that the product improved ignition/propellant system is as safe as the current standard system.

COPY/vr

AMSTE-BC 3 MAR 1969

SUBJECT: Directive for Product Improvement Test of Cartridge, 81-MM, HE, M374 with Reduced Bourrelet and Waterproofed Ignition/ Propellant System, USATECOM Project No. 8-9-3010-20

10. Security: Test materiel, data and reports will be unclassified.

FOR THE COMMANDER:

/s/ C. J. Molloy, Jr.
/t/ C. J. MOLLOY, JR.
Colonel, GS
Dir, Inf Mat Test Dir

3 Incl w/d
1. Msg, AMCPM-MT
2. STE Form 1028
3. Dist List

Copies furnished: (w/o incl)
Pres USAIB
CG USAMUCOM ATTN: AMCPM-MT
AMSMU-RE
CO PA ATTN: SMUPA-DA4

COPY/vr

DEPARTMENT OF THE ARMY Mr.Nelson/bkd/234-
U. S. ARMY BALLISTIC RESEARCH LABORATORIES 3350-3661
ABERDEEN PROVING GROUND, MARYLAND 21005

AMXRD-BEL 18 June 1969

SUBJECT: Velocity Uniformity Study of 81-MM Cartridges, HE, M374 with Modifications

Commanding General
Aberdeen Proving Ground
ATTN: STEAP-MT-TA
Mr. R. Holwager
Aberdeen Proving Ground, Maryland 21005

1. Reference: Telecon between your Mr. R. Holwager and Mr. W. Nelson of these laboratories, 5 June 1969, concerning velocity uniformity of the subject ammunition.

2. Analysis of velocity test data taken at Aberdeen Proving Ground during May 1969 has been completed as requested. The analysis revealed a definite difference in velocity levels between the standard Cartridge, HE, M374 and Cartridge, HE, M374 with rotating band and propellant bag modifications.

3. Corrections to existing unabridged firing tables can be made without additional firings. Abridged firing tables for this cartridge would have to be recomputed since no allowances are made for nonstandard conditions in these tables.

FOR THE DIRECTOR:

/s/ Charles H. Lebegern, Jr.
/t/ CHARLES H. LEBEGERN, JR.
Chief, Firing Tables Branch, EBL

DEPARTMENT OF THE ARMY
U S ARMY BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND 21005

AMXRD-BEL 2 July 1969

SUBJECT: Velocity Uniformity Comparison for 81mm Cartridges, HE, M374 (standard) and M374 with Reduced Bourrelet and Celcon/Silk Propellant Bags

Commanding General
Aberdeen Proving Ground
ATTN: STEAP-MT-TA
Mr. R. Holwager
Aberdeen Proving Ground, Md. 21005

1. Reference: Telecon between your Mr. R. Holwager and Mr. W. Nelson of these laboratories, 5 June 1969, concerning velocity uniformity of the subject ammunition.

2. Analysis of test data taken at Aberdeen Proving Ground during May 1969 reveals different velocity levels between the subject cartridges.

3. Corrections to existing unabridged firing tables can be made with present data. A recomputation would be necessary for the abridged firing table since no allowances are made for nonstandard conditions in these tables.

FOR THE DIRECTOR:

Charles H. Lebegern, Jr.
CHARLES H. LEBEGERN, JR.
Chief, Firing Tables Branch

APPENDIX IV - REFERENCES

1. Orendorf, W. M., Final Report on Product Improvement Test of Cartridge, 81-MM, HE, M374 (Waterproofing of Cartridge, M374). USATECOM Project No. 8-MU-001-374-001. Aberdeen Proving Ground. Report No. APG-MT-3279, August 1969.

2. Miller, G. P., Final Report on Product Improvement Test of Cartridge, 81-MM, HE, M374 with Celcon Obturator. USATECOM Project No. 8-MU-001-374-005. Aberdeen Proving Ground. (Test not complete. Expected date of report, August 1969.)

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

Materiel Test Directorate
Aberdeen Proving Ground, Md. 21005

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

PRODUCT IMPROVEMENT TEST OF CARTRIDGE, 81-MM, HE, M374, WITH REDUCED BOURRELET AND WATERPROOF IGNITION - PROPELLANT SYSTEM

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Final Report 1 May to 12 June 1969

5. AUTHOR(S) *(First name, middle initial, last name)*

Harvey W. Cheater

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1969	63	2

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
Not applicable	APG-MT-3285
b. PROJECT NO. USATECOM Project No. 8-MU-001-374-008	
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

10. DISTRIBUTION STATEMENT

This document may be further distributed by any holder only with specific prior approval of Project Manager, US Army Munitions Command, ATTN: AMCPM-MT.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
None	USAMUCOM

13. ABSTRACT

A product improvement test was conducted at Aberdeen Proving Ground on an 81-mm cartridge, HE, M374, modified with a reduced hourrelet and a waterproof ignition - propellant system from 1 May to 12 June 1969. This test was conducted to determine whether the modifications to the round provided waterproofness properties to the propellant without adversely affecting velocity, pressure, and range and without introducing safety or human-factors problems. The test round was found to be only a marginal improvement over the standard round in eliminating short rounds following waterproofness tests. Velocity levels were significantly higher for the test round at all charges but charge 4 when compared with the standard round at +70°F. This difference would require an adjustment of the propellant charge or a correction to the existing firing tables. Residue did not appear to be a problem nor was safety degraded by the modification. Cook-off properties were remarkably different in that the test round is launched at apparent full velocity. The obvious advantage is that a live round does not impact close to the mortar position. If established misfire-removal procedures are followed, no safety problem is created. The test bags required significantly longer time (as much as 75% longer) to assemble to the round than the cotton increment and are more susceptible to detaching from the round during rough-handling tests. However, the latter can be prevented by assembling the test rounds with protective muffs. It is concluded that the test cartridge provides a replacement for the present standard round with some moisture protection but not to the degree of being a suitable water - moisture resistant round and that the difference in velocity levels of the two cartridge types is significant. No human-factors or safety problems were encountered.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Product Improvement test Cartridge, 81-mm, M374 Reduced bourrelet Waterproof ignition-propellant system Celcon/silk propellant bags Mylar-wrapped ignition cartridge Delrin obturating band Residue test Velocity uniformity Puddle, immersion and rain tests Cook-off test Rough-handling and transportation - vibration tests						